

ANNEX L

Methodology for Estimating CH₄ Emissions from Enteric Fermentation

Methane emissions from enteric fermentation were estimated for five livestock categories: cattle, horses, sheep, swine, and goats. Emissions from cattle represent the majority of U.S. emissions; consequently, the more detailed IPCC Tier 2 methodology was used to estimate emissions from cattle and the IPCC Tier 1 methodology was used to estimate emissions from the other types of livestock.

Estimate Methane Emissions from Cattle

This section describes the process used to estimate methane emissions from cattle enteric fermentation. A model based on recommendations provided in IPCC/UNEP/OECD/IEA (1997) and IPCC (2000) was developed that uses information on population, energy requirements, digestible energy, and methane conversion rates to estimate methane emissions. The emission methodology consists of the following three steps: (1) characterize the cattle population to account for animal population categories with different emissions profiles; (2) characterize cattle diets to generate information needed to estimate emissions factors; and (3) estimate emissions using these data and the IPCC Tier 2 equations.

Step 1: Characterize U.S. Cattle Population

Each stage in the cattle lifecycle was modeled to simulate the cattle population from birth to slaughter. This level of detail accounts for the variability in methane emissions associated with each life stage. Given that the time in which cattle can be in a stage can be less than one year (e.g., beef calves are weaned at 7 months), the stages are modeled on a per month basis. The type of cattle use also impacts methane emissions (e.g., beef versus dairy). Consequently, cattle life stages were modeled for several categories of dairy and beef cattle. These categories are listed in Table L-1.

Table L-1: Cattle Population Categories Used for Estimating Methane Emissions

Dairy Cattle	Beef Cattle
Calves	Calves
Heifer Replacements	Heifer Replacements
Cows	Heifer and Steer Stockers
	Animals in Feedlots
	Cows
	Bulls

The key variables tracked for each of these cattle population categories (except bulls¹) are as follows:

- *Calving rates:* The number of animals born on a monthly basis was used to initiate monthly cohorts and to determine population age structure. The number of calves born each month was obtained by multiplying annual births by the percentage of births by month. Annual birth information for each year was taken from USDA (2002a, 2001a, 2000a, 1999a, 1995a). Average percentages of births by month for beef from USDA (USDA/APHIS/VS 1998, 1994, 1993) were used for 1990 through 2001. For dairy animals, birth rates were assumed constant throughout the year. Whether calves were born to dairy or beef cows was estimated using the dairy cow calving rate and the total dairy cow population to determine the percent of births attributable to dairy cows, with the remainder assumed to be attributable to beef cows.
- *Average weights and weight gains:* Average weights were tracked for each monthly age group using starting weight and monthly weight gain estimates. Weight gain (i.e., pounds per month) was estimated based on weight gain needed to reach a set target weight, divided by the number of months remaining before target weight was achieved. Birth weight was assumed to be 88 pounds for both beef and dairy

¹ Only end-of-year census population statistics and a national emission factors are used to estimate methane emissions from the bull population.

animals. Weaning weights were estimated to range from 480 to 575 pounds. Other reported target weights were available for 12, 15, 24, and 36 month-old animals. Live slaughter weights were derived from dressed slaughter weight data for each year (USDA 2002c, 2001c, 2000c, 1999a, 1995a). Live slaughter weight was estimated as dressed weight divided by 0.63.

- *Feedlot placements:* Feedlot placement statistics were available that specify placement of animals from the stocker population into feedlots on a monthly basis by weight class. The model used these data to shift a sufficient number of animals from the stocker cohorts into the feedlot populations to match the reported placement data. After animals are placed in feedlots they progress through two steps. First, animals spend time on a step-up diet to become acclimated to the new feed type. Animals are then switched to a finishing diet for a period of time before they are slaughtered. The length of time an animal spends in a feedlot depends on the start weight (i.e., placement weight), the rate of weight gain during the start-up and finishing phase of diet, and the end weight (as determined by weights at slaughter). Weight gain during start-up diets is estimated to be 2.8 to 3 pounds per day. Weight gain during finishing diets is estimated to be 3 to 3.3 pounds per day (Johnson 1999). All animals are estimated to spend 25 days in the step-up diet phase (Johnson 1999). Length of time finishing was calculated based on start weight, weight gain per day, and target slaughter weight.
- *Pregnancy and lactation:* Energy requirements and hence, composition of diets, level of intake, and emissions for particular animals, are greatly influenced by whether the animal is pregnant or lactating. Information is therefore needed on the percentage of all mature animals that are pregnant each month, as well as milk production, to estimate methane emissions. A weighted average percent of pregnant cows each month was estimated using information on births by month and average pregnancy term. For beef cattle, a weighted average total milk production per animal per month was estimated using information on typical lactation cycles and amounts (NRC 1999), and data on births by month. This process results in a range of weighted monthly lactation estimates expressed as lbs/animal/month. The monthly estimates from January to December are 3.33, 5.06, 8.70, 12.01, 13.58, 13.32, 11.67, 9.34, 6.88, 4.45, 3.04, and 2.77 lbs milk/animal/month. Monthly estimates for dairy cattle were taken from USDA monthly milk production statistics.
- *Death rates:* This factor is applied to all heifer and steer cohorts to account for death loss within the model on a monthly basis. The death rates are estimated by determining the death rate that results in model estimates of the end-of-year population for cows that match the published end-of-year population census statistics.
- *Number of animals per category each month:* The population of animals per category is calculated based on number of births (or graduates) into the monthly age group minus those animals that die or are slaughtered and those that graduate to the next category (including feedlot placements). These monthly age groups are tracked in the enteric fermentation model to estimate emissions by animal type on a regional basis.
- *Animal characteristic data:* Dairy lactation estimates for 1990 through 2001 are shown in Table L-2. Table L-3 provides the target weights used to track average weights of cattle by animal type. Table L-4 provides a summary of the reported feedlot placement statistics for 2001. Data on feedlot placements were available for 1996 through 2001. Data for 1990 to 1995 were based on the average of monthly placements from the 1996 to 1998 reported figures.

Cattle population data were taken from U.S. Department of Agriculture (USDA) National Agricultural Statistics Service (NASS) reports. A summary of the annual average populations upon which all livestock-related emissions are based is provided in Table M-1 of Annex M, Methodology for Estimating CH₄ and N₂O Emissions from Manure Management. The USDA publishes monthly, annual, and multi-year livestock population and production estimates. Multi-year reports include revisions to earlier published data. Cattle and calf populations, feedlot placement statistics (e.g., number of animals placed in feedlots by weight class), slaughter numbers, and lactation data were obtained from the USDA (2002a, 2002c, 2001a, 2002c, 2000a, 2000c, 1999a, 1995a). Beef calf birth percentages were obtained from the National Animal Health Monitoring System (NAHMS) (USDA/APHIS/VS 1998, 1994, 1993).

Step 2: Characterize U.S. Cattle Population Diets

To support development of digestible energy (DE, the percent of gross energy intake digestible to the animal) and methane conversion rate (Y_m , the fraction of gross energy converted to methane) values for each of the cattle population categories, data were collected on diets considered representative of different regions. For both grazing animals and animals being fed mixed rations, representative regional diets were estimated using information collected from state livestock specialists and from USDA (1996a). The data for each of the diets (e.g., proportions of different feed constituents, such as hay or grains) were used to determine chemical composition for use in estimating digestible energy and Y_m for each animal type. Additional detail on the regional diet characterization is provided in EPA (2000).

Digestible energy and Y_m vary by diet and animal type. The IPCC recommends Y_m values of 3.5 to 4.5 percent for feedlot cattle and 5.5 to 6.5 percent for all other cattle. Given the availability of detailed diet information for different regions and animal types in the United States, digestible energy and Y_m values unique to the United States² were developed. Table L-7 shows the regional digestible energy, the Y_m , and percent of total U.S. cattle population in each region based on 2001 data. Digestible energy and Y_m values were estimated for each cattle population category, for each year in the time series based on physiological modeling, published values, and/or expert opinion.

Digestible energy and Y_m values for dairy cows were estimated using a model (Donovan and Baldwin 1999) that represents physiological processes in the ruminant animals. The three major categories of input required by the model are animal description (e.g., cattle type, mature weight), animal performance (e.g., initial and final weight, age at start of period), and feed characteristics (e.g., chemical composition, habitat, grain or forage). Data used to simulate ruminant digestion is provided for a particular animal that is then used to represent a group of animals with similar characteristics. The model accounts for differing diets (i.e., grain-based, forage-based, range-based), so that Y_m values for the variable feeding characteristics within the U.S. cattle population can be estimated.

To calculate the digestible energy values for grazing beef cattle, the diet descriptions were used to estimate weighted digestible energy values for a combination of forage only and supplemented diets. Where digestible energy values were not available for specific feed types, total digestible nutrients (TDN) as a percent of dry matter (DM) intake was used as a proxy for digestible energy as it is essentially the same as the digestible energy value. For forage diets, two separate regional digestible energy values were used to account for the generally lower forage quality in the western US. For non-western grazing animals, the forage digestible energy was an average of the seasonal “TDN percent DM” for Grass Pasture diets listed in Appendix Table 1 of the NRC (2000). This average digestible energy for the non-western grazing animals was 64.7 percent. This value was used for all regions except the west. For western grazing animals, the forage digestible energy was calculated as the average “TDN percent DM” for meadow and range diets listed in Appendix Table 1 of the NRC (2000). The calculated digestible energy for western grazing animals was 58.5 percent. The supplemental diet digestible energy values were estimated for each specific feed component, as shown in Table L-5, along with the percent of each feed type in each region. Finally, weighted averages were developed for digestible energy values for each region using both the supplemental diet and the forage diet³. For beef cows, the digestible energy value was adjusted downward by two percent to reflect the reduced diet of the mature beef cow. The percent of each diet that is assumed to be supplemental and the digestible energy values for each region are shown in Table L-6. Y_m values for all grazing beef cattle were set at 6.5 percent based on Johnson (2002).

For feedlot animals, digestible energy and Y_m values for 1996 through 2001 were taken from Johnson (1999). Values for 1990 through 1995 were linearly extrapolated from the 1996 value based on Johnson (1999). In response to peer reviewer comments (Johnson 2000), values for dairy replacement heifers are based on EPA (1993).

² In some cases, the Y_m values used for this analysis extend beyond the range provided by the IPCC. However, EPA believes that these values are representative for the U.S. due to the research conducted to characterize the diets of U.S. cattle and to assess the Y_m values associated with different animal performance and feed characteristics in the United States.

³ For example, in California the forage DE of 64.7 was used for 95 percent of the grazing cattle diet and a supplemental diet DE of 65.2 percent was used for five percent of the diet, for a total weighted DE of 64.9 percent.

Step 3: Estimate Methane Emissions from Cattle

Emissions were estimated in three steps: a) determine gross energy (GE) intake using the IPCC (2000) equations, b) determine an emissions factor using the GE values and other factors, and c) sum the daily emissions for each animal type. The necessary data values include:

- Body Weight (kg)
- Weight Gain (kg/day)
- Net Energy for Activity (C_a)⁴
- Standard Reference Weight⁵ (Dairy = 1,324 kg; Beef = 1,195 kg)
- Milk Production (kg/day)
- Milk Fat (percent of fat in milk = 4)
- Pregnancy (percent of population that is pregnant)
- DE (percent of gross energy intake digestible)
- Y_m (the fraction of gross energy converted to methane)

Step 3a: Gross Energy, GE

As shown in the following equation, gross energy (GE) is derived based on the net energy estimates and the feed characteristics. Only variables relevant to each animal category are used (e.g., estimates for feedlot animals do not require the NE_l factor). All net energy equations are provided in IPCC (2000).

$$GE = [((NE_m + NE_{mobilized} + NE_a + NE_l + NE_p) / \{NE_{ma}/DE\}) + (NE_g / \{NE_{ga}/DE\})] / (DE / 100)$$

Where:

GE = gross energy (MJ/day)

NE_m = net energy required by the animal for maintenance (MJ/day)

$NE_{mobilized}$ = net energy due to weight loss (mobilized) (MJ/day)

NE_a = net energy for animal activity (MJ/day)

NE_l = net energy for lactation (MJ/day)

NE_p = net energy required for pregnancy (MJ/day)

$\{NE_{ma}/DE\}$ = ratio of net energy available in a diet for maintenance to digestible energy consumed

NE_g = net energy needed for growth (MJ/day)

$\{NE_{ga}/DE\}$ = ratio of net energy available for growth in a diet to digestible energy consumed

DE = digestible energy expressed as a percentage of gross energy (percent)

Step 3b: Emission Factor

The emissions factor (DayEmit) was determined using the gross energy value and the methane conversion factor (Y_m) for each category. This is shown in the following equation:

$$\text{DayEmit} = [GE \times Y_m] / [55.65 \text{ MJ/kg CH}_4]$$

Where:

DayEmit = emission factor (kg CH₄/head/day)

⁴ Zero for feedlot conditions, 0.17 for high quality confined pasture conditions, 0.36 for extensive open range or hilly terrain grazing conditions. C_a factor for dairy cows is weighted to account for the fraction of the population in the region that grazes during the year.

⁵ Standard Reference Weight is used in the model to account for breed potential.

GE = gross energy intake (MJ/head/day)

Y_m = methane conversion rate which is the fraction of gross energy in feed converted to methane (percent)

The daily emission factors were estimated for each animal type, weight and region.

Step 3c: Estimate Total Emissions

Emissions were summed for each month and for each population category using the daily emission factor for a representative animal and the number of animals in the category. The following equation was used:

$$\text{Emissions} = \text{DayEmit} \times \text{Days/Month} \times \text{SubPop}$$

Where:

DayEmit = the emission factor for the subcategory (kg CH₄/head/day)

Days/Month = the number of days in the month

SubPop = the number of animals in the subcategory during the month

This process was repeated for each month, and the totals for each subcategory were summed to achieve an emissions estimate for the entire year. The estimates for each of the 10 subcategories of cattle are listed in Table L-8. The emissions for each subcategory were then summed to estimate total emissions from beef cattle and dairy cattle for the entire year.

Emission Estimates from Other Livestock

All livestock population data, except for horses, were taken from U.S. Department of Agriculture (USDA) National Agricultural Statistics Service (NASS) reports. Table M-1 of Annex M shows the population data for all livestock species that were used for estimating all livestock-related emissions. For each animal category, the USDA publishes monthly, annual, and multi-year livestock population and production estimates. Multi-year reports include revisions to earlier published data. Recent reports were obtained from the USDA Economics and Statistics System, while historical data were downloaded from the USDA-NASS. The Food and Agriculture Organization (FAO) publishes horse population data. These data were accessed from the FAOSTAT database at <http://apps.fao.org/>. Methane emissions from sheep, goats, swine, and horses were estimated by multiplying published national population estimates by the national emission factor for each year. Table L-9 shows the emission factors used for these other livestock.

A complete time series of enteric fermentation emissions from all livestock types is shown in Table L-10 (Tg CO₂ Eq.) and Table L-11 (Gg).

Table L-2: Dairy Lactation by Region (lbs·year/cow)*

Year	California	West	Northern Great		Southcentral	Northeast	Midwest	Southeast
			Plains					
1990	18,443	17,293	13,431		13,399	14,557	14,214	12,852
1991	18,522	17,615	13,525		13,216	14,985	14,446	13,053
1992	18,709	18,083	13,998		13,656	15,688	14,999	13,451
1993	18,839	18,253	14,090		14,027	15,602	15,086	13,739
1994	20,190	18,802	14,686		14,395	15,732	15,276	14,111
1995	19,559	18,708	14,807		14,294	16,254	15,680	14,318
1996	19,148	19,076	15,040		14,402	16,271	15,651	14,232
1997	19,815	19,537	15,396		14,330	16,519	16,116	14,517
1998	19,461	19,814	15,922		14,722	16,865	16,676	14,404
1999	20,763	20,495	16,378		14,986	17,271	16,966	14,860
2000	21,134	20,782	17,297		15,314	17,484	17,426	15,196
2001	20,898	20,656	17,347		14,813	17,602	17,218	15,303

Source: USDA (2002d, 2001d, 2000d, 1999a, 1995a).

* Beef lactation data were developed using the methodology described in the text.

Table L-3: Target Weights for Use in Estimating Average Weights and Weight Gains (lbs)

Cattle Type	Typical Weights
Beef Replacement Heifer Data	
Replacement Weight at 15 months	715
Replacement Weight at 24 months	1,078
Mature Weight at 36 months	1,172
Dairy Replacement Heifer Data	
Replacement Weight at 15 months	800
Replacement Weight at 24 months	1,225
Mature Weight at 36 months	1,350
Stockers Data – Grazing/Forage Based Only	
Steer Weight Gain/Month to 12 months	45
Steer Weight Gain/Month to 24 months	35
Heifer Weight Gain/Month to 12 months	35
Heifer Weight Gain/Month to 24 months	30

Source: Feedstuffs (1998), Western Dairyman (1998), Johnson (1999), NRC (1999).

Table L-4: Feedlot Placements in the United States for 2001¹ (Number of animals placed in Thousand Head)

Weight When Placed	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
< 600 lbs	499	336	329	334	499	419	469	510	528	891	655	418	5,887
600 - 700 lbs	716	402	414	384	509	442	444	472	448	758	588	475	6,052
700 - 800 lbs	664	517	614	494	799	631	606	667	561	592	381	413	6,939
> 800 lbs	384	325	485	339	565	473	467	555	604	461	284	272	5,214
Total	2,263	1,580	1,842	1,551	2,372	1,965	1,986	2,204	2,141	2,702	1,908	1,578	22,184

Source: USDA (2002f, 2001f, 2000f, 1999a, 1995a).

Note: Totals may not sum due to independent rounding.

Table L-5: DE Values and Representative Regional Diets (Percent of Diet for each Region) for the Supplemental Diet of Grazing Beef Cattle

Feed	Source of TDN (NRC 2000)	Unweighted TDN or DE	California	West	Northern Great Plains	Southcentral	Northeast	Midwest	Southeast
Alfalfa Hay	Table 11-1, feed #4	59.6%	65%	30%	30%	29%	12%	30%	
Barley	Table 11-1, feed #12	86.3%	10%	15%					
Bermuda	Table 11-1, feed #17	48.5%							35%
Bermuda Hay	Table 11-1, feed #17	48.5%				40%			
Corn	Table 11-1, feed #38	88.1%	10%	10%	25%	11%	13%	13%	
Corn Silage	Table 11-1, feed #39	71.2%			25%		20%	20%	
Cotton Seed Meal	Table 11-1, feed #42	74.4%				7%			
Grass Hay	Table 1a, feed #129, 147, 148	53.7%		40%				30%	
Orchard	Table 11-1, feed #61	53.5%							40%
Soybean Meal Supplement	Table 11-1, feed #70	83.1%		5%	5%				5%
Sorghum	Table 11-1, feed #67	81.3%							20%
Soybean Hulls	Table 11-1, feed #69	76.4%						7%	
Timothy Hay	Table 11-1, feed #77	55.5%					50%		
Whole Cotton Seed	Table 11-1, feed #41	89.2%	5%				5%		
Wheat Middlings	Table 1a, feed #433	83.0%			15%	13%			
Wheat	Table 11-1, feed #83	87.2%	10%						
Weighted Total			65.2%	65.1%	62.4%	65.0%	74.3%	58.8%	69.3%

Source of representative regional diets: Donovan (1999)

L-6 Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2001

Table L-6: Percent of each Diet that is Supplemental, and the Resulting DE Values for each Region

Region	Percent Supplement	Percent Forage	Calculated Weighted Average DE
West	10	90	59.2%
Northeast	15	85	64.7%
Southcentral	10	90	64.4%
Midwest	15	85	64.7%
Northern Great Plains	15	85	66.1%
Southeast	5	95	64.4%
California	5	95	64.9%

Source of percent of total diet that is supplemental diet: Donovan (1999)

Table L-7: Regional Digestible Energy (DE), Methane Conversion Rates (Y_m), and population percentages for Cattle in 2001

Animal Type	Data	California	West	Northern Great Plains	Southcentral	Northeast	Midwest	Southeast
Beef Repl. Heif.	DE ^a	65	59	66	64	65	65	64
	Y _m ^b	6.5%	6.5%	6.5%	6.5%	6.5%	6.5%	6.5%
	Pop. ^c	3%	10%	31%	23%	2%	14%	17%
Dairy Repl. Heif.	DE	66	66	66	64	68	66	66
	Y _m	5.9%	5.9%	5.6%	6.4%	6.3%	5.6%	6.9%
	Pop.	18%	12%	5%	4%	18%	36%	7%
Steer Stockers	DE	65	59	66	64	65	65	64
	Y _m	6.5%	6.5%	6.5%	6.5%	6.5%	6.5%	6.5%
	Pop.	4%	8%	42%	22%	2%	18%	5%
Heifer Stockers	DE	65	59	66	64	65	65	64
	Y _m	6.5%	6.5%	6.5%	6.5%	6.5%	6.5%	6.5%
	Pop.	2%	7%	50%	22%	1%	15%	4%
Steer Feedlot	DE	85	85	85	85	85	85	85
	Y _m	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%
	Pop.	3%	8%	48%	24%	1%	16%	1%
Heifer Feedlot	DE	85	85	85	85	85	85	85
	Y _m	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%
	Pop.	3%	8%	48%	24%	1%	16%	1%
Beef Cows	DE	63	57	64	62	63	63	62
	Y _m	6.5%	6.5%	6.5%	6.5%	6.5%	6.5%	6.5%
	Pop.	2%	8%	28%	26%	2%	14%	19%
Dairy Cows	DE	69	66	69	68	69	69	68
	Y _m	4.8%	5.8%	5.8%	5.7%	5.8%	5.8%	5.6%
	Pop.	17%	13%	5%	6%	18%	33%	8%
Steer Step-Up	DE	73	73	73	73	73	73	73
	Y _m	4.8%	4.8%	4.8%	4.8%	4.8%	4.8%	4.8%
Heifer Step-Up	DE	73	73	73	73	73	73	73
	Y _m	4.8%	4.8%	4.8%	4.8%	4.8%	4.8%	4.8%

^a Digestible Energy in units of percent GE (MJ/Day).

^b Methane Conversion Rate is the fraction of GE in feed converted to methane.

^c Percent of each subcategory population present in each region.

Table L-8: CH₄ Emissions from Cattle (Gg)

Cattle Type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Dairy	1,375	1,378	1,375	1,316	1,314	1,320	1,254	1,255	1,251	1,266	1,284	1,282
Cows	1,142	1,148	1,143	1,082	1,082	1,088	1,024	1,028	1,026	1,038	1,059	1,055
Replacements 7-11 months	49	49	49	49	49	49	48	48	48	48	48	48
Replacements 12-23 months	184	181	183	185	183	183	181	179	177	180	177	179
Beef	3,961	3,920	4,031	4,070	4,147	4,272	4,227	4,124	4,046	4,035	3,976	3,936
Cows	2,428	2,432	2,468	2,494	2,585	2,628	2,638	2,574	2,531	2,520	2,506	2,492
Replacements 7-11 months	52	54	57	60	62	61	60	56	54	53	53	54
Replacements 12-23 months	190	196	203	216	229	232	225	216	206	198	198	200
Steer Stockers	430	402	464	482	435	479	455	430	418	393	369	372
Heifer Stockers	231	220	233	240	231	249	239	241	236	227	213	215
Feedlot Cattle	413	397	384	353	374	383	371	375	378	420	416	384
Bulls	218	220	222	224	231	239	239	233	223	224	220	219
Total	5,336	5,298	5,406	5,385	5,461	5,591	5,481	5,379	5,297	5,300	5,260	5,218

Note: Totals may not sum due to independent rounding.

Table L-9: Emission Factors for Other Livestock (kg CH₄/head/year)

Livestock Type	Emission Factor
Sheep	8
Goats	5
Horses	18
Swine	1.5

Source: IPCC (2000).

Table L-10: CH₄ Emissions from Enteric Fermentation (Tg CO₂ Eq.)

Livestock Type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Beef Cattle	83.2	82.3	84.7	85.5	87.1	89.7	88.8	86.6	85.0	84.7	83.5	82.7
Dairy Cattle	28.9	28.9	28.9	27.6	27.6	27.7	26.3	26.4	26.3	26.6	27.0	26.9
Horses	1.9	1.9	1.9	1.9	1.9	1.9	1.9	2.0	2.0	2.0	2.0	2.0
Sheep	1.9	1.9	1.8	1.7	1.7	1.5	1.4	1.3	1.3	1.2	1.2	1.2
Swine	1.7	1.8	1.8	1.8	1.9	1.9	1.8	1.8	2.0	1.9	1.9	1.9
Goats	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Total	117.9	117.1	119.4	118.8	120.4	123.0	120.5	118.3	116.7	116.6	115.7	114.8

Table L-11: CH₄ Emissions from Enteric Fermentation (Gg)

Livestock Type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Beef Cattle	3,961	3,920	4,031	4,070	4,147	4,272	4,227	4,124	4,046	4,035	3,976	3,936
Dairy Cattle	1,375	1,378	1,375	1,316	1,314	1,320	1,254	1,255	1,251	1,266	1,284	1,282
Horses	91	92	92	92	92	92	93	93	94	93	94	95
Sheep	91	89	86	82	79	72	68	64	63	58	56	56
Swine	81	85	88	87	90	88	84	88	93	90	88	88
Goats	13	13	13	12	12	11	10	10	10	10	10	10
Total	5,612	5,576	5,685	5,658	5,733	5,855	5,737	5,635	5,557	5,551	5,509	5,468